



In-Situ Thermal Remediation: Steam Enhanced Extraction (SSE) at Site 4 Former Underground Storage Tanks, Bethpage NY

Presented By
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Objective



- **Thermal treatment technology overview**

- Fundamental principles
- Technologies

- **Site 4 Characterization**

- **Treatability Study**

- **Remedial Objectives**

- **System design**

- **Cost considerations**

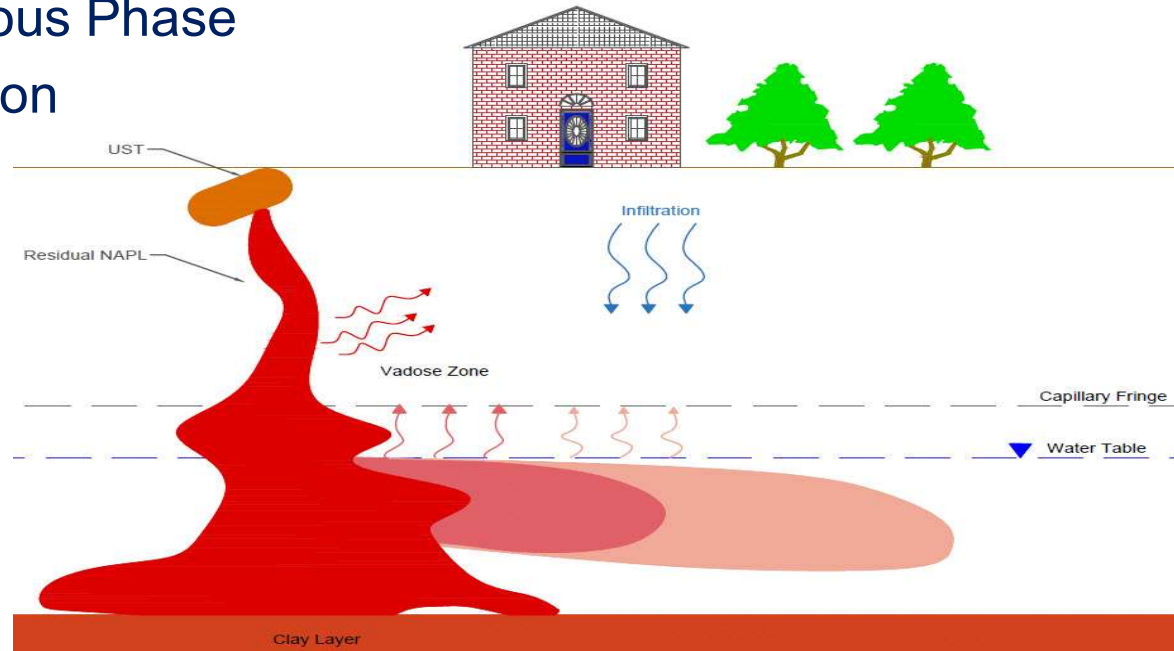
- **Summary**



Thermal Treatment Technology Overview



- Application of heat to the subsurface to enhance the removal of organic contaminants
- Aggressive remedial technology
- Typically applied for source area removal
- Often used in combination with other technologies
 - Groundwater/Non Aqueous Phase Liquid (NAPL) Extraction
 - Soil Vapor Extraction
 - Bioremediation

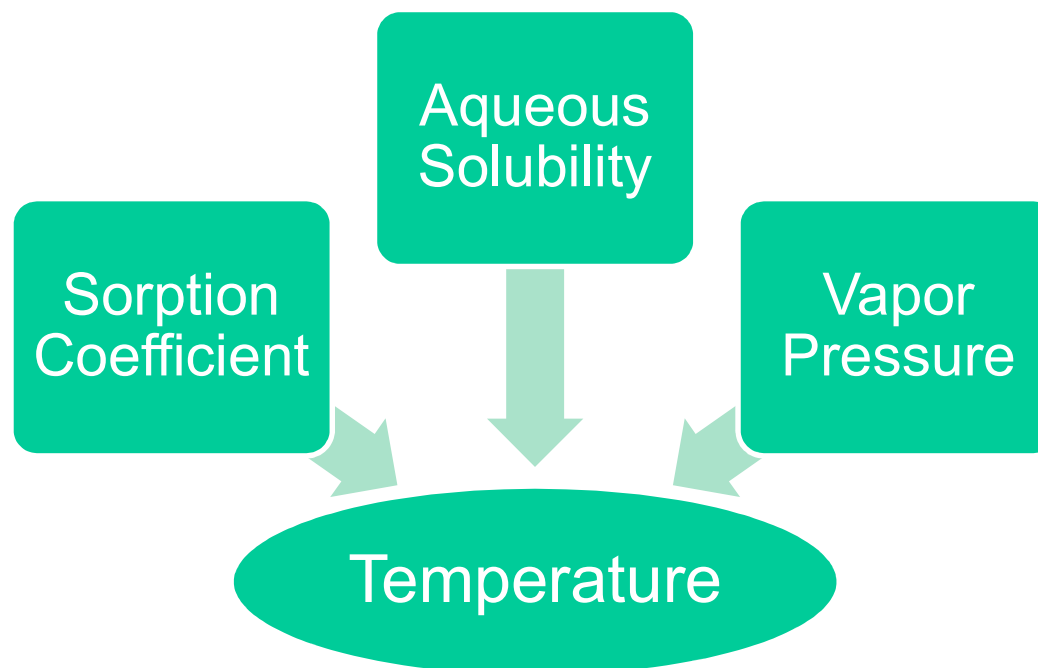


Thermal Treatment Technology Overview



- **Increasing temperature:**

- **↓ Soil – water sorption coefficient**
- **↑ Aqueous solubility**
- **↑ Vapor pressure**



Thermal Treatment Technology Overview

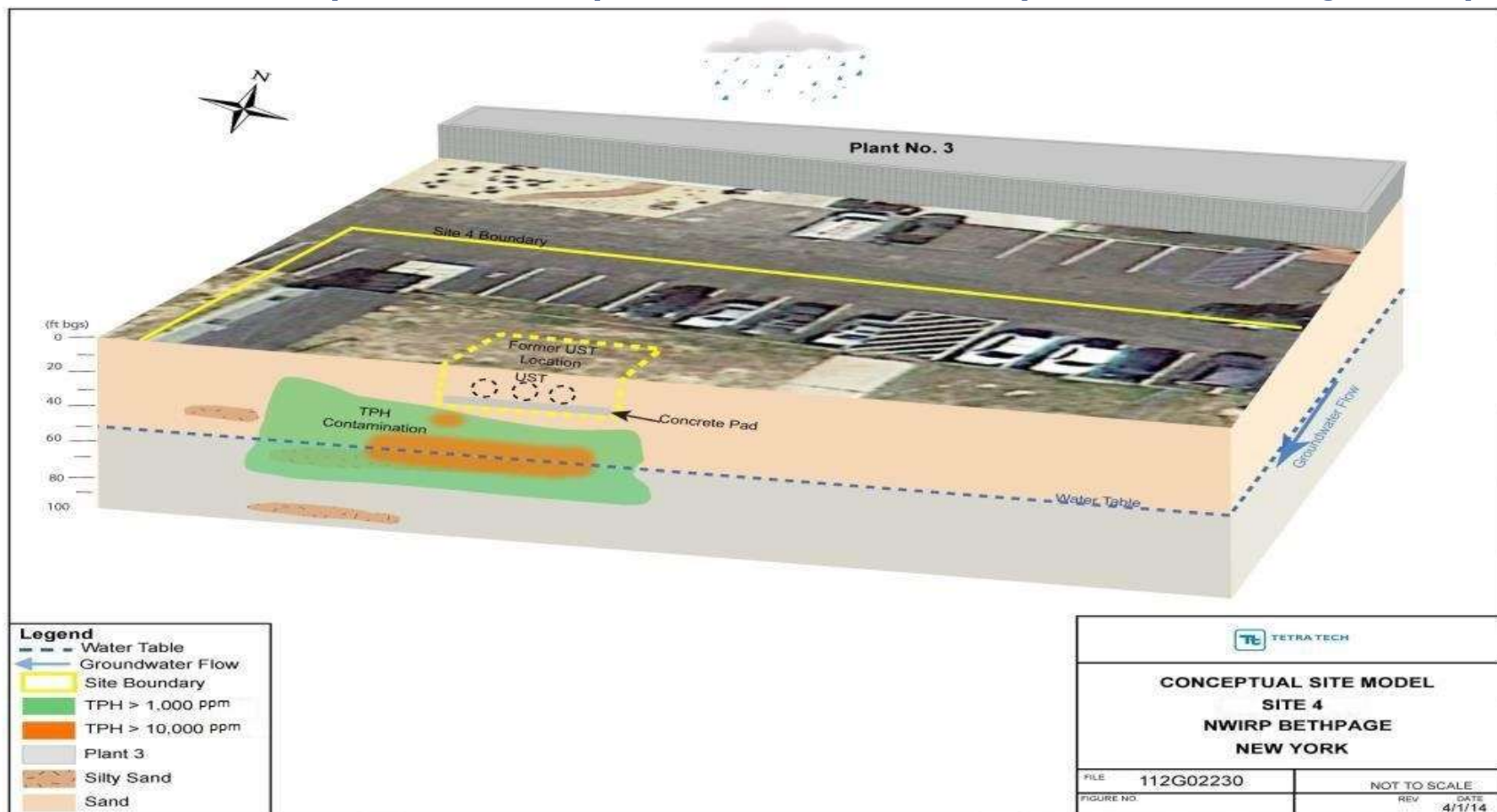


- **Electrical Resistance Heating (ERH)**
- **Radio Frequency Heating**
- **Injection of Hot Air, Water or Steam**
- **Thermal conductive heating (TCH)**

Site 4 Characterization



- Underground storage tanks (UST)
- No.6 Fuel Oil (1941 – 66); No.4 Fuel Oil (1966 – early 80s)



Site 4 Characterization



- **Geology:**

- glacial deposits consisting of coarse sands and gravels
- finer-grained sediments more common at depths below 50' bgs
- porosity: 24.4%

- **Hydrogeology:**

- groundwater flow south and southwest. Depth to GW ~50 ft
- average horizontal hydraulic conductivity 55 feet/day

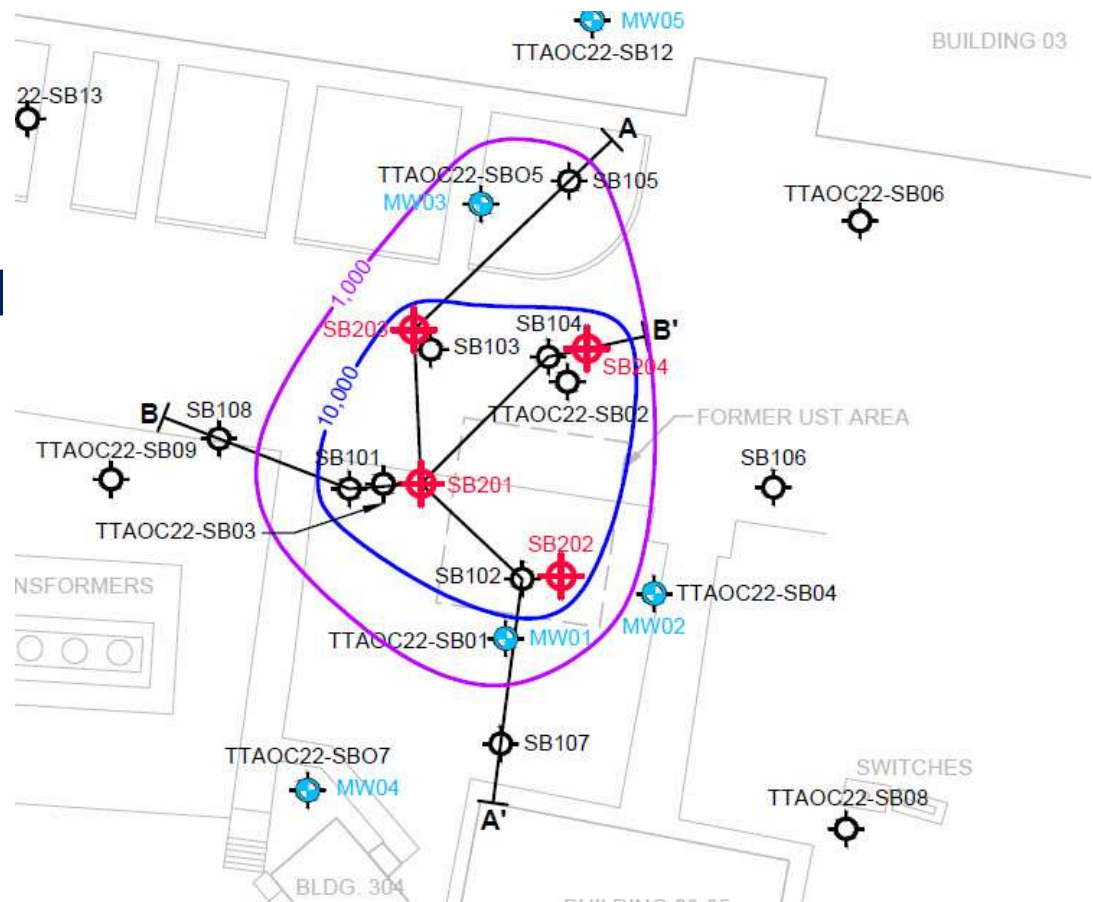
- **Site COCs**

- Soil: PAHs associated with petroleum
 - Exceed NYSDEC Soil Cleanup Objectives (unrestricted use and protection of groundwater)
 - NYSDEC requires removal of TPH that forms free product
- Groundwater: VOCs, SVOCs

Site 4 Characterization



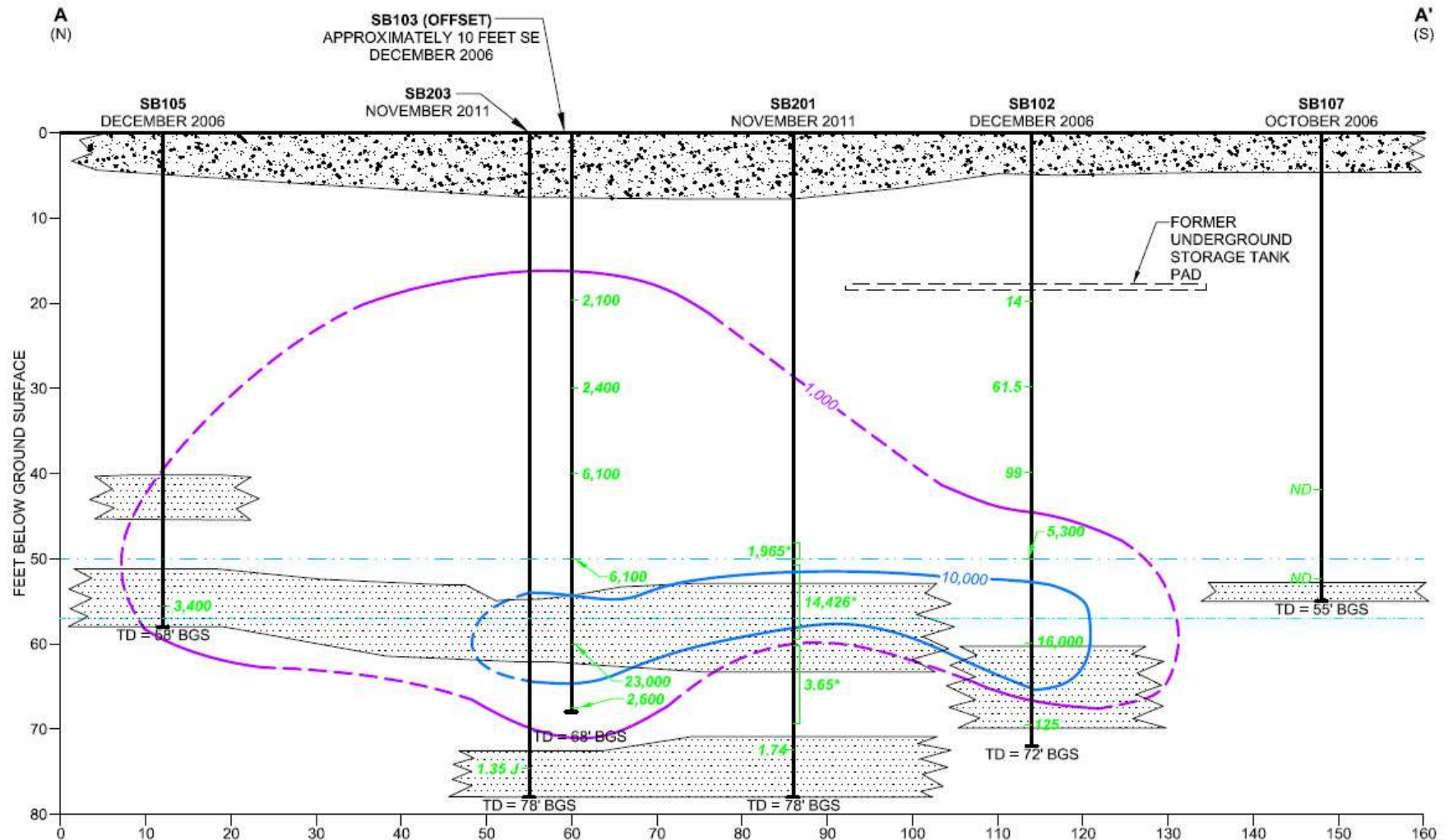
- Petroleum contaminated soil and semi – solid petroleum products are present near and below the groundwater table
- Areal extent: 0.14 acres
- Max TPH: 50,000 ppm
- < ¼ inch NAPL observed in MW01 and MW02



Site 4 Characterization



• Cross section A – A'



Treatability Study



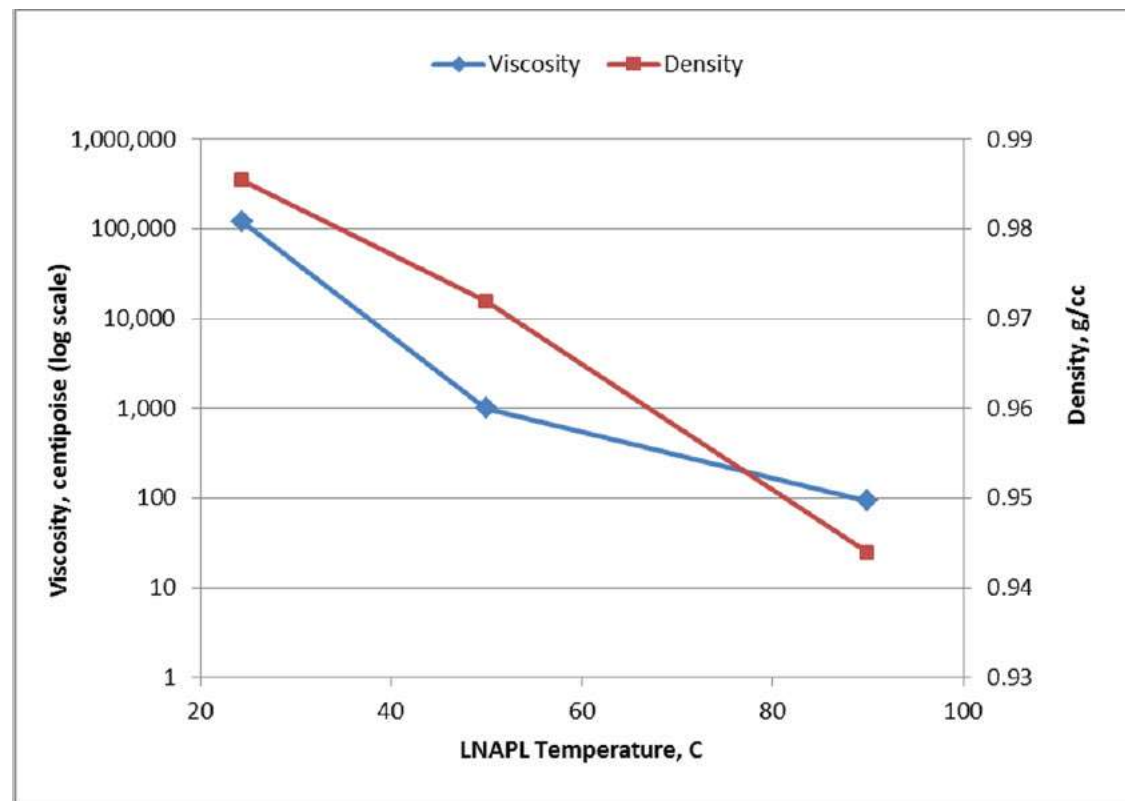
- **Understand NAPL characteristics over a range of temperatures**
- **Determine effectiveness of hot water flushing and steam enhanced extraction to remove NAPL and reduce concentration of COCs**
- **Understand the leaching potential of Polycyclic Aromatic Hydrocarbons (PAHs) following thermal treatments.**

Treatability Study



- **NAPL characteristics**

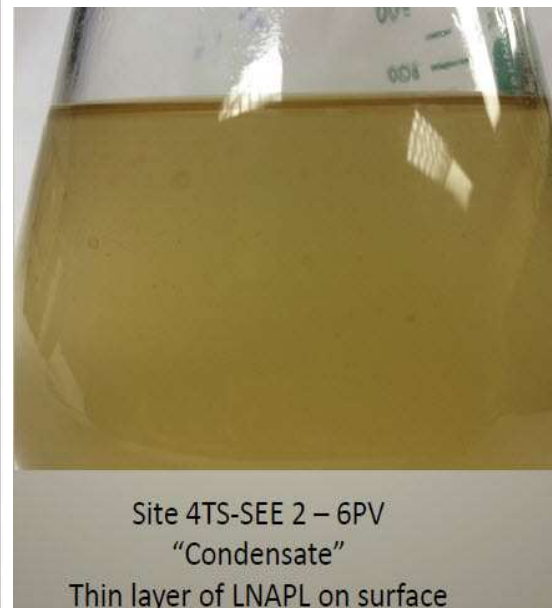
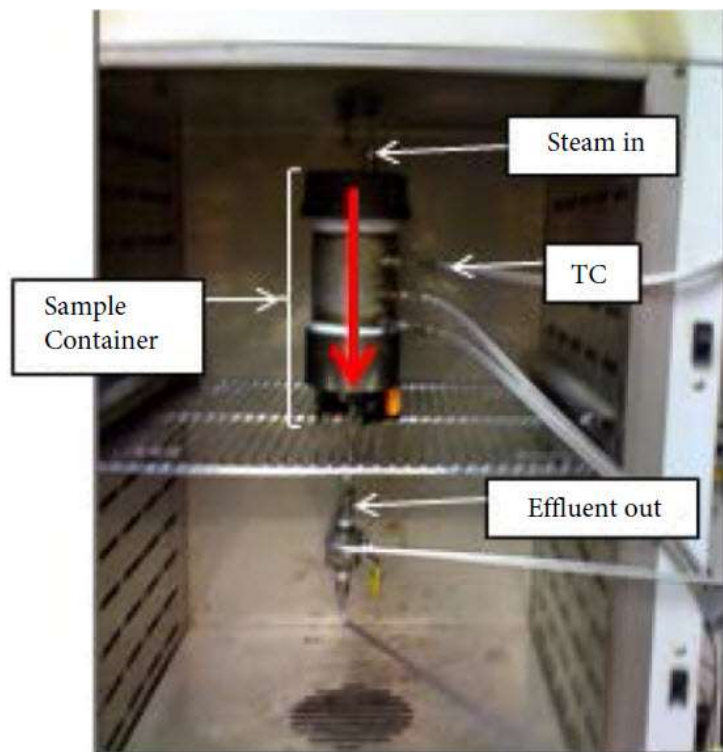
- resists flow at ambient conditions
- temperatures at or greater than 90 °C necessary to enhance extraction
- density is less than water



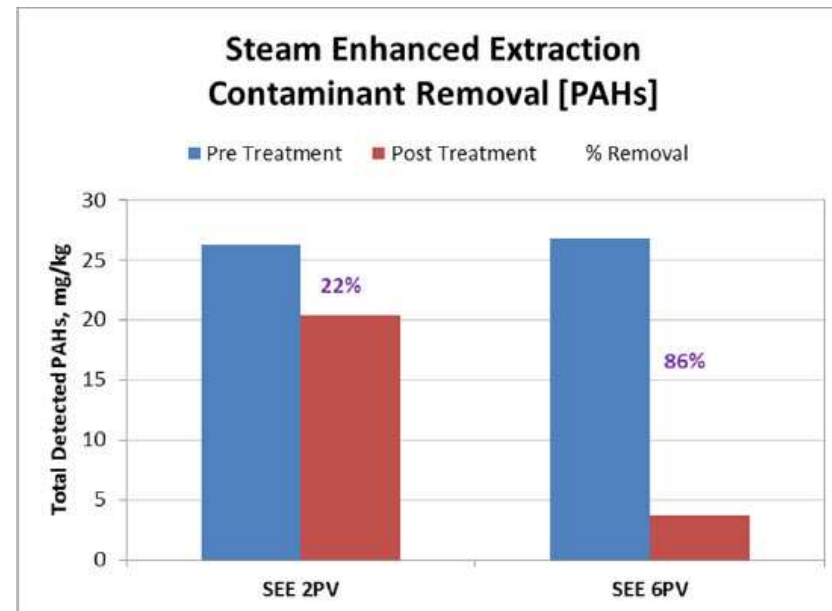
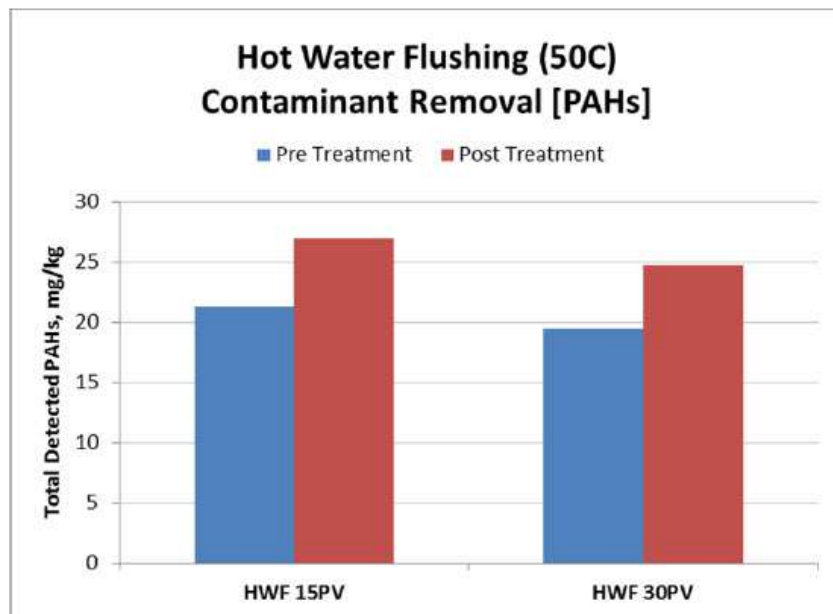
Treatability Study



- Steam Enhanced Extraction: 2 pore volume (PV) and 6PV
- Hot water flushing: 15PV and 30PV



Treatability Study



- Did not effectively remove NAPL or PAHs from soil
- Longer duration did not improve PAH or NAPL removal
- Limited PAH and NAPL removal
- Removal improved with longer duration

System Design

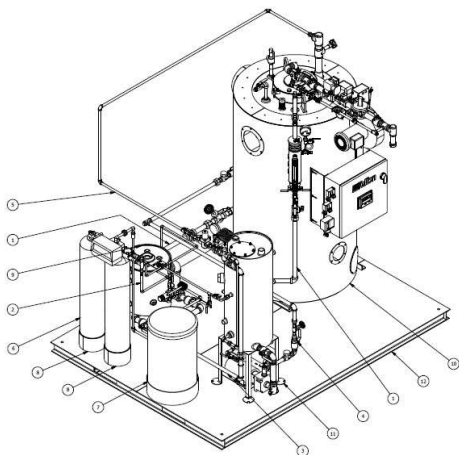


- **Steam injection**

- Target area: soils greater than 10,000 mg/kg TPH
- Estimated 8,860 gallons of NAPL present Site wide
- Anticipate 50% recovery
- Steam injected outside, below and above target treatment zone
- Heat treatment zone to between 120 – 210 °F

- **Recovery well captures mobilized NAPL**

- **Positive displacement pump, extraction piping will be heated**



- »Utilizes approximately 2 gallons water per minute
- »Creates 1,000 pounds steam per hour
- »Injected at around 15 psi through six steam injection wells

System Design

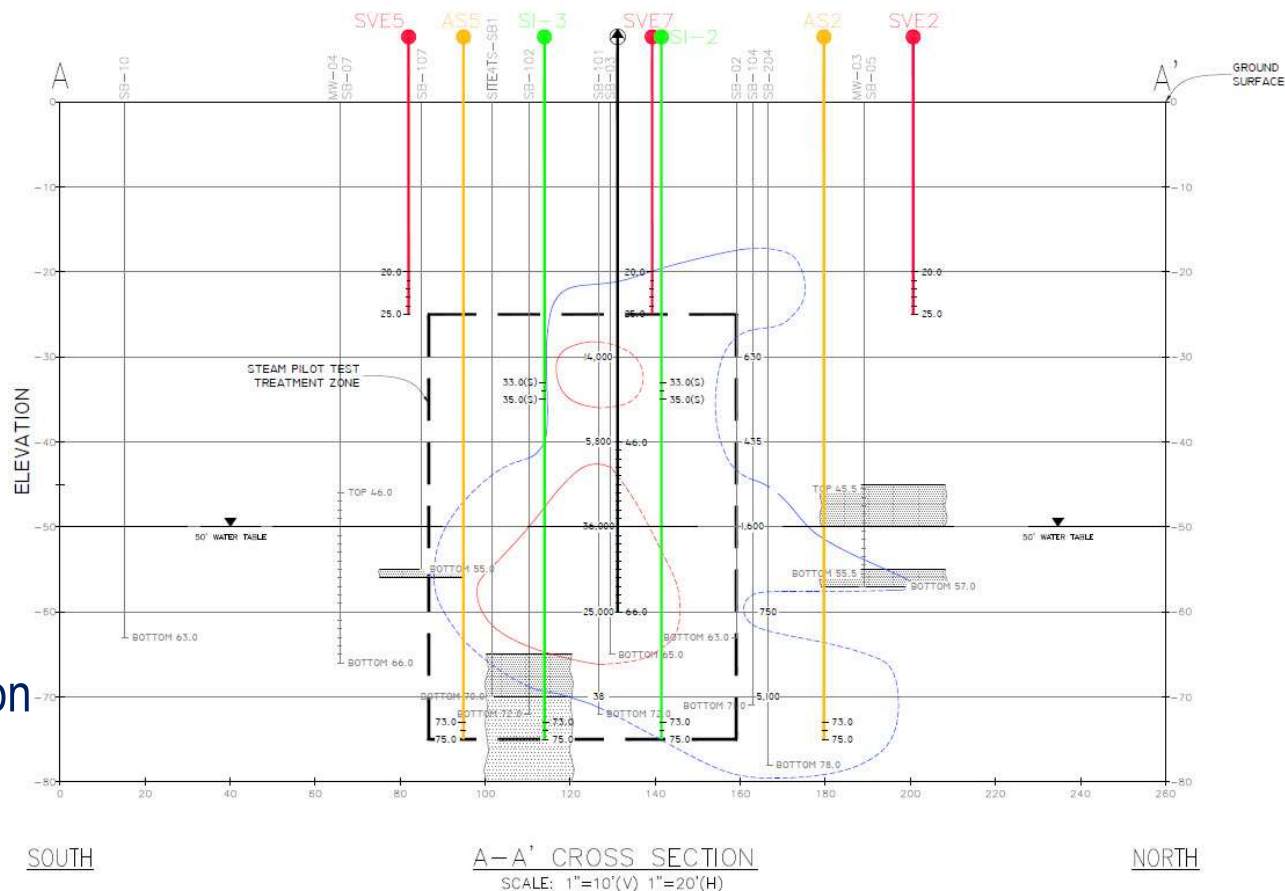


- **Soil Vapor Extraction**

- Operate in conjunction with steam injection and bioparging
- Capture contaminants volatilized

- **Bioparging**

- Promote biodegradation of remaining contamination
- Target the area of 1,000 mg/kg TPH



System Design



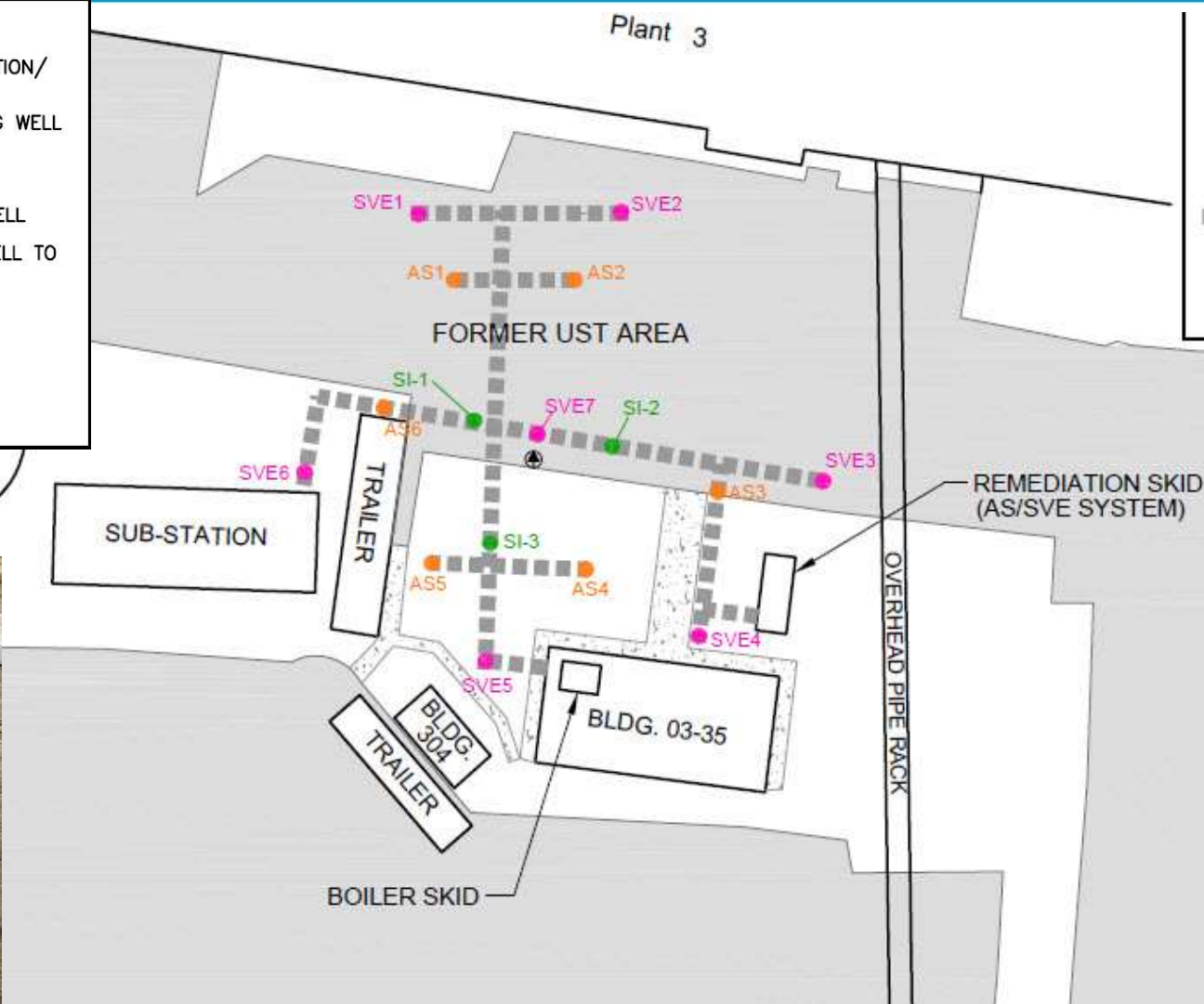
LEGEND:

- PROPOSED STEAM INJECTION/
AIR SPARGING WELL
- PROPOSED AIR SPARGING WELL
- PROPOSED SOIL VAPOR
EXTRACTION WELL
- ⊕ PROPOSED RECOVERY WELL
- ⊖ EXISTING MONITORING WELL TO
TO BE ABANDONED

■ TRENCH

■ CONCRETE

■ ASPHALT



System Design



- **Steam injection and NAPL recovery**

- Discontinue when recovery becomes asymptotic (8 months)
- Soil samples collected prior to and at conclusion of steam injection

- **Biosparging**

- Soil samples collected to determine system effectiveness after 4 years

- **SVE**

- Discontinue when biosparging ends

- **Monitor soil vapor and groundwater**



System Costs



- **Construction Cost – \$ 0.8 million**

- includes construction of all remedial systems; wells trenching, piping, mechanical components

- **Non-Construction Cost – \$0.4 million**

- design, permitting, program management

- **Operating Cost – \$0.7 million**

- operation and maintenance (O&M) of steam injection/NAPL recovery for 8 months, O&M of biosparge and SVE systems for 4 years

- **Approximately \$245 per CY of soil**

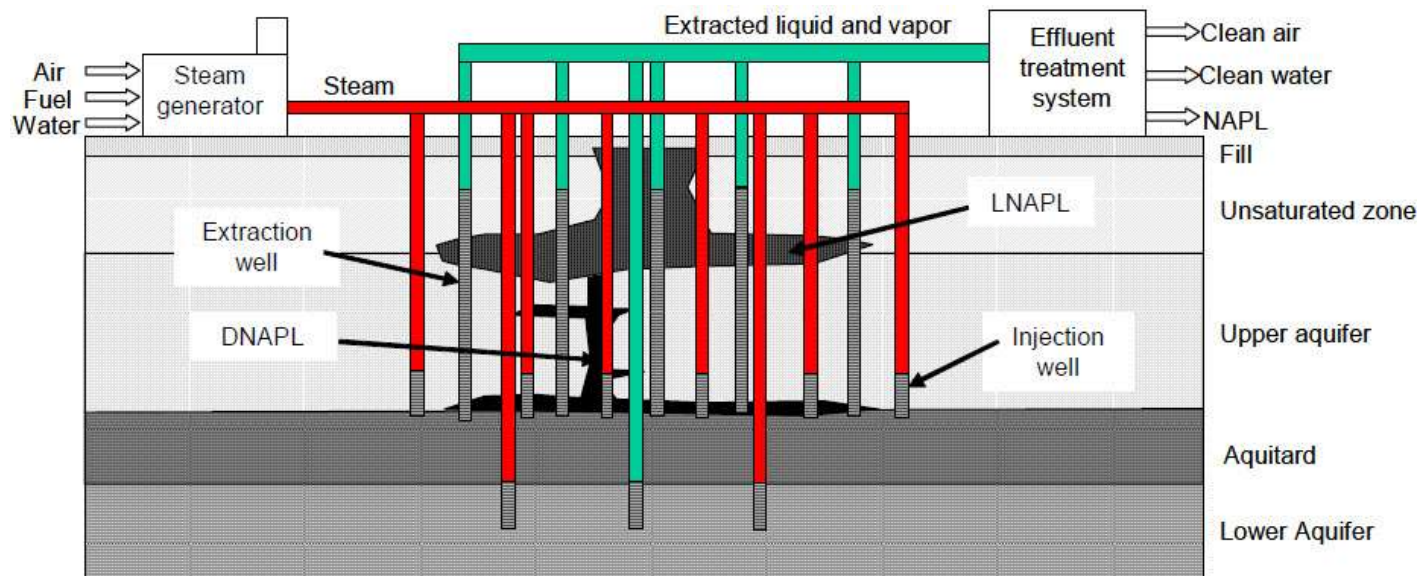
- (Estimated 7,700 CY of impacted soil)

Summary



- **Thermal treatment technologies**

- Enhance contaminant recovery
- Shorten cleanup times
- Eliminate the need for excavation
- Can be applied for a variety of organic contaminants and various site conditions



Contacts and Questions



Points of Contact

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Questions ?

Supplemental Information



Websites for additional information:

- <https://clu-in.org/>
- <https://frtr.gov/costperformance/remediation/#19>
- http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_200-1-21.pdf?ver=2014-05-08-155746-393